The association between nutritional status and household sanitation among rural children in the Tibetan and Sichuan minority areas: a cross-sectional study

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Abstract

Background: To investigate the nutritional status and household sanitation among children under 5 in Tibetan and Sichuan minority areas and to analyse the association between nutritional status and household sanitation. Methods: A cross-sectional survey was conducted by the probability proportional to size sampling method between August and October 2016. Nutritional status was evaluated according to the standards of growth and development recommended by the World Health Organization. Bivariate and multivariate logistic regression analyses were used to analyse the association between nutritional status and household sanitation.

Results: A total of 965 children under the age of 5 and their caregivers were included. The rates of normal development, stunting, underweight, wasting, overweight and obesity of children in Sichuan and Tibet were 69.0%, 19.8%, 8.0%, 5.2%, 4.6% and 1.8%, respectively. The multivariable logistic regression analyses shows that other unprotected water sources (AOR=3.21, 95%CI=1.41~7.32), unboiled drinking water (AOR=2.05, 95%CI=1.41~2.97), sanitary and dry toilets (AOR=2.04, 95%CI=1.12~3.71), unsanitary and dry toilets (AOR=2.80, 95%CI=1.42~5.51), usually do not washing hands at critical times (AOR=2.11, 95%CI=1.15~3.90), washing hands only with water (AOR=1.53, 95%CI=1.03~2.26) and unsanitary treatment of children's faeces (AOR=1.56, 95%CI=1.11~2.20) were the risk factors for stunting in children. Protected well water (AOR=4.28, 95%CI=1.46~12.52), other unprotected water sources (AOR=4.30, 95%CI=1.36~13.61), unsanitary and dry toilets (AOR=4.44, 95%CI=1.26~15.59), washing hands at only one critical moment (AOR=2.77, 95%CI=1.15~6.65), washing hands only with water (AOR=2.22, 95%CI=1.20~4.09) and unsanitary treatment of children’s faeces (AOR=2.01, 95%CI=1.23~3.28) were risk factors for underweight in children.

Conclusion: The malnutrition of children under 5 years of age in the rural areas home to ethnic minorities in Sichuan and Tibet is serious, and the problem of stunting is particularly prominent. The children's household sanitation status is poor, and the family's economic income has an impact on household sanitation; thus, household sanitation has an impact on both the height and the weight of the child. The relevant departments should increase the family's economic income while conducting household sanitation interventions, thereby reducing the incidence and mortality due to malnutrition.

Background

The World Health Organization (WHO) estimated in 2018 that approximately 52 million children under the age of 5 are wasting, 17 million are severely wasting, 155 million are stunted, 41 million are overweight/obese, and approximately 45% of deaths among children under 5 are related to malnutrition [1]. Children aged 0 ~ 5 years old are the age group most likely to suffer malnutrition, and nutritional status in the early stage of life is directly related to subsequent growth and development, learning, cognitive ability and even labour productivity in adulthood [2–4]. In 2012, the World Health Assembly planned to reduce global under-five malnutrition to less than 100 million children by 2025 and to end all forms of malnutrition by 2030 [5–6].

The incidence of child malnutrition has decreased greatly since China's economic reform. In 1990, the rate of stunting among children under 5 years of age in China was 31.3%, and the rate of underweight was 7.4%. In 2010, these figures decreased to 9.4% and 3.4%, respectively [7]. However, the differences between urban and rural areas and regions cannot be ignored; the rates are obviously higher in rural areas than in urban areas, and the rates are obviously higher in poor areas than in economically developed areas [8–11]. A previous study showed that the rate of stunting among children under 5 years of age was 15.9%, the underweight rate was 7.8%, and the wasting rate was 3.7% in poor areas of China [12]. In 2017, the National Nutrition Plan issued by the State Council of China (2017–2030) explicitly stated that the rate of stunting among children under 5 should be less than 7% in 2020 and below 5% in 2030, indicating the main development goal of child nutrition [13].

Tibet and Yi nationality areas of Sichuan are located in western China, which is a relatively backward economic area. In addition, the Tibetan and Yi ethnic minorities are the two of the most representative ethnic minorities in China, with the most complete national customs and habits and the most prominent national characteristics. A survey conducted in 2011 showed that the rates of stunting, underweight and wasting among children in the minority areas of Sichuan and Tibet were 30.5%, 16.5% and 1.6%, respectively [14], which are much higher than those of children in other parts of China; therefore, these children should receive increasing attention from relevant Chinese and international bodies.

Household sanitation refers to all family-related sanitation, including household sanitation facilities, such as toilets, drinking water sanitation and the hygiene behaviour of caregivers and children. There are many factors that affect the malnutrition of children, mainly including the family financial situation, the child's age, feeding habits, hygiene behaviour and the child's state of health. Studies have shown that there is a clear correlation between childhood acute malnutrition and family environmental hygiene [15–17]. However, there are few studies on the effect of household sanitation on chronic malnutrition in children in China. Therefore, the purpose of this study is to analyse the association between household sanitation and the nutritional status of children and to provide a scientific basis for improving the nutritional status of rural children in poor minority areas and promoting the healthy growth of children.

Methods

Study population

A cross-sectional survey was conducted from August to October 2016, and the main investigated areas were Ganluo County and Yuexi County in Liangshan Yi Autonomous Prefecture of Sichuan and Saga County and Aung Ren County in Xigaze region of Tibet. The study population included children under 5 years of age and their caregivers. The inclusion criteria were as follows: 1. The children's age range: the children were born after the date of the 2011 survey; 2. Long-term local residence: the local residence time was 2/3 greater than the child's age. The exclusion criterion was that the children were not at home at the time of the investigation.

Sampling Methods

The probability proportional to size (PPS) sampling was used to select sample villages. The main steps were as follows: step 1: 15 administrative villages were randomly selected in each county according to the PPS sampling method; step 2: 2 natural villages in each administrative village were randomly selected by PPS sampling; step 3: In Sichuan, after the natural village was determined, 8 caregivers were randomly selected from each natural village according to the family roster containing children under 5 years of age. In Tibet, administrative villages could not be divided into natural villages, and 5 caregivers were randomly selected from each administrative village according to the family roster containing children under 5 years of age. If a sample village failed to meet the proposed sample size, another sample village was randomly selected in the same layer until the intended sample size was achieved. The number of people surveyed in each county of Sichuan needed to reach 240, and the number of people surveyed in each county of Tibet needed to reach 70. At least 620 caregivers of children under the age of five were investigated in Sichuan and Tibet. (8 or 5 households in each natural village were chosen for the survey because the Tibetan and Sichuan Yi areas are sparsely populated.)

Survey Tool

The survey was conducted using the questionnaire designed by the Maternal and Child Health Project expert group. The main contents included the basic characteristics of the children and their caregivers, the feeding situation of the children, the situation of household sanitation and the physical examination of the children (height and weight), etc.

Data Collection and Quality Control

All investigators were uniformly trained, with an investigation team of 4 to 5 qualified investigators led by local village doctors. Using one-on-one question and answer, the investigators filled out questionnaires on the panel computer on the spot. The questionnaires were checked one by one by the investigators and team leaders on the night of the survey and uploaded to the database. Finally, the data verification was carried out by the evaluation team of Peking University. The physical examination of each child was carried out by two investigators using standardized equipment in accordance with the international standard method of measurement [18]. The body length in bed was measured for children less than or equal to 2 years old, and the standing height was measured for children older than 2 years old. Each child's length/height and weight were measured twice to take the mean value. A third measurement was required if the error of the two measures was greater than 0.05 kg for weight and more than 0.1 cm for length/height.

Definitions

1. Evaluation indicators: child growth and development standards published by the WHO in 2006 [18]. Length/height-for-age (HAZ) < median - 2 standard deviation (M-2SD) was considered stunting; weight-for-age (WAZ) < M-2SD was considered underweight; weight-for-height (WHZ) < M-2SD was

considered wasting, M+2SD ~ M+3SD was considered overweight, >M+3SD was considered obese; children without stunting, underweight, wasting, overweight and obesity were defined as normally developing.

2. The children were divided into 5 groups according to their age in months: 0~11 months, 12~23 months, 24~35 months, 36~47 months, and 48~59 months.
3. Washing hands at critical moments: a total of 8 critical moments are listed, namely, after the completion of agricultural work, before cooking, before dining, before feeding the baby, after defecation, after handling the child's faeces, other and usually do not wash hands. The analysis was grouped by number, and the four groups include the option usually do not wash hands, 1, 2, 3 and above.

Statistical Analysis

The data were downloaded directly from the database into the statistical software and analysed by IBMSPSS 21.0 software. The Shapiro-Wilk test and Q-Q plots were used to check for normality of the continuous variables. The statistical analysis methods used mainly include the following: the basic characteristics of children and caregivers were described by the constituent ratio, the difference was compared adopting the chi-square test, and the influencing factors were analysed by bivariate and multivariate logistic regression analysis. All statistical analyses were two-tailed, and an α of 0.05 denoted statistical significance.

Results

Basic Characteristics of Children and Their Caregivers

A total of 965 children under 5 and their caregivers were included in this study. Of these, 51.7% were boys; those aged 0~, 12~, 24~, 36 ~ and 48 ~ 59 months accounted for 33.5%, 28.2%, 20.7%, 10.5% and 7.2%, respectively. By location, those in Sichuan accounted for 84.5%, and those in Tibet accounted for 15.5%; Yi represented the largest proportion by nationality, with 71.7%. A total of 721 (74.7%) mothers were surveyed, of whom 85.4% were illiterate/had primary school education; there were 438 (45.4%) missing values for household per capita net income. Incomes of 0~, 2000 ~ and ≥ 5000 yuan were reported by 36.8%, 40.0% and 23.1% of the families, respectively. (Table 1)

Table 1
Basic characteristics of children and their caregivers (n = 965)

Variables		n	%
Gender	boy	499	51.7
	girl	466	48.3
Age(month)	0~	323	33.5
	12~	272	28.2
	24~	200	20.7
	36~	101	10.5
	48 ~ 59	69	7.2
Area	Sichuan	815	84.5
	Tibet	150	15.5
Nationality	Han	117	12.1
	Yi	692	71.7
	Tibetan	156	16.2
Caregivers	mother	721	74.7
	others	244	25.3
Mother's educational level	illiterate / primary school	616	85.4
(n = 721)	junior middle school	88	12.2
	senior high school and above	17	2.4
Family income (yuan)	0~	194	36.8
(n = 527)	2000~	211	40.0
	≥ 5000	122	23.1

Nutritional Status of Children

The rates of stunting, underweight, wasting, overweight, obesity and normal development among the children were 19.8%, 8.0%, 5.2%, 4.6%, 1.8% and 69.0%, respectively. There were significant differences in the normal development rate, stunting rate, overweight rate and obesity rate among children of different ages. There were significant differences in the normal development rate, stunting rate and overweight rate among boys of different ages. The differences in the normal developmental rate, stunting rate and obesity rate among girls of different ages were statistically significant. With increasing age, the rate of

normally developing children decreased, and the minimum normal development rate among boys between 48 and 59 months was 55.0%. With the increase in the age of the child, the rate of stunting increased, and the rate of stunting of boys of 48 ~ 59 months was up to 37.5%. (Table 2)

Table 2
Assessment of the status of children's malnutrition (n = 965) (%)

Gender	Age (month)	Stunting	Underweight	Wasting	Overweight	Obesity	Normal development
Boys	0~	6.2	6.8	8.0	8.0	2.5	74.1
	12~	18.8	6.9	3.5	2.1	0	73.6
	24~	30.4	8.8	4.9	2.9	2.0	62.7
	36~	29.4	3.9	2.0	2.0	2.0	64.7
	48 ~ 59	37.5	5.0	5.0	10.0	0	55.0
	total	19.6	6.8	5.2	4.8	1.4	69.1
χ^2		33.596[a]	1.532	4.592	10.031	6.593	7.819[a]
P		< 0.001	0.821	0.332	0.040	0.159	0.005
Girls	0~	5.6	6.8	5.6	6.2	4.3	75.2
	12~	21.1	10.9	4.7	1.6	0	72.7
	24~	33.7	9.2	5.1	4.1	3.1	58.2
	36~	32.0	8.0	4.0	6.0	0	62.0
	48 ~ 59	27.6	17.2	6.9	3.4	0	65.5
	total	20.0	9.2	5.2	4.3	2.1	68.9
χ^2		27.759[a]	3.863	0.437	4.181	12.202	6.269[a]
P		< 0.001	0.425	0.979	0.382	0.016	0.012
Total	0~	5.9	6.8	6.8	7.1	3.4	74.6
	12~	19.9	8.8	4.0	1.8	0	73.2
	24~	32.0	9.0	5.0	3.5	2.5	60.5
	36~	30.7	5.9	3.0	4.0	1.0	63.4
	48 ~ 59	33.3	10.1	5.8	7.2	0	59.4
	total	19.8	8.0	5.2	4.6	1.8	69.0
χ^2		61.302[a]	2.161	3.534	11.242	17.063	14.069[a]
P		< 0.001	0.706	0.473	0.024	0.002	< 0.001

Note: a: linear trend chi-square test.

Household Sanitation of Children

Among these 965 households, the source of water was purified tap water (16.0%), water was boiled before drinking (42.8%), the toilet was flushed (13.0%), hands were washed at three or more critical moments (16.5%), hands were washed with soap (36.4%) and the child's faeces were treated hygienically (59.4%). The results showed that there were significant differences in drinking water source, whether water was boiled before drinking, toilet type, hand washing at critical moments, washing hand mode and treatment of children's faeces among families with different incomes. (Table 3)

Table 3

Comparison of the household sanitation of children in different family income (n = 527)

Varaibles		Family income (%)			χ^2	P
		0~	2000~	≥ 5000		
Drinking water source	purified tap water	33(17.0)	28(13.3)	44(36.1)	28.469	< 0.001
	protected well water	21(10.8)	31(14.7)	13(10.7)		
	unprotected well water	125(64.4)	132(62.6)	58(47.5)		
	others	15(7.7)	20(9.5)	7(5.7)		
Boiling before drinking	boiled	68(35.1)	111(52.6)	76(62.3)	24.768	< 0.001
	unboiled	126(64.9)	100(47.4)	46(37.7)		
Toilet type	flush sanitary toilet	18(9.3)	22(10.4)	31(25.4)	39.831	< 0.001
	flush unsanitary toilet	1(0.5)	17(8.1)	6(4.9)		
	sanitary and dry toilet	123(63.4)	137(64.9)	70(57.4)		
	unsanitary and dry toilet	52(26.8)	35(16.6)	15(12.3)		
Washing hands at critical moments	usually don not wash hands	27(13.9)	22(10.4)	6(4.9)	17.377	0.008
	one	89(45.9)	81(38.4)	48(39.3)		
	two	54(27.8)	65(30.8)	34(27.9)		
	three and above	24(12.4)	43(20.4)	34(27.9)		
Washing hand mode	soap	49(25.3)	74(35.1)	60(49.2)	18.929	< 0.001
	only water	145(74.7)	137(64.9)	62(50.8)		
Child's faeces treatment	sanitary	99(51.0)	128(60.7)	85(69.7)	11.087	0.004
	unsanitary	95(49.0)	83(39.3)	37(30.3)		

The Association between Nutritional Status and Household Sanitation

After adjusting for factors such as age, gender and region, other unprotected water sources (AOR = 3.21, 95%CI = 1.41 ~ 7.32), unboiled drinking water (AOR = 2.05, 95%CI = 1.41 ~ 2.97), sanitary and dry toilets (AOR = 2.04, 95%CI = 1.12 ~ 3.71), unsanitary and dry toilets (AOR = 2.80, 95%CI = 1.42 ~ 5.51), usually do not washing hands at critical moments (AOR = 2.11, 95%CI = 1.15 ~ 3.90), washing hands only with water (AOR = 1.53, 95%CI = 1.03 ~ 2.26), and unsanitary treatment of children's faeces (AOR = 1.56, 95%CI = 1.11 ~ 2.20) were risk factors for stunting in children.

After adjusting for factors such as age, gender and region, protected well water (AOR = 4.28, 95%CI = 1.46 ~ 12.52), other unprotected water sources (AOR = 4.30, 95%CI = 1.36 ~ 13.61), unsanitary and dry toilets (AOR = 4.44, 95%CI = 1.26 ~ 15.59), washing hands at only one critical moment (AOR = 2.77, 95%CI = 1.15 ~ 6.65), washing hands only with water (AOR = 2.22, 95%CI = 1.20 ~ 4.09) and unsanitary treatment of children's faeces (AOR = 2.01, 95%CI = 1.23 ~ 3.28) were risk factors for underweight in children. (Table 4)

Table 4

The effect of the different household sanitation on the nutritional status of children

Varaibles		Morbidity rate(%)	COR(95%CI)	P	AOR(95%CI)	P
Stunting						
Drinking water source	purified tap water	13.6	1		1	
	protected well water	25.6	2.18(1.12 ~ 4.25)	0.022	1.98(0.92 ~ 4.24)	0.081
	unprotected well water	19.4	1.52(0.92 ~ 2.51)	0.100	1.38(0.82 ~ 2.31)	0.223
	others	31.3	2.88(1.43 ~ 5.80)	0.003	3.21(1.41 ~ 7.32)	0.005
Boiling before drinking	boiled	15.0	1		1	
	unboiled	23.4	1.73(1.24 ~ 2.41)	0.001	2.05(1.41 ~ 2.97)	< 0.001
Toilet type	flush sanitary toilet	12.0	1		1	
	flush unsanitary toilet	17.3	1.54(0.63 ~ 3.77)	0.350	1.91(0.75 ~ 4.85)	0.173
	sanitary and dry toilet	19.8	1.82(1.02 ~ 3.22)	0.042	2.04(1.12 ~ 3.71)	0.020
	unsanitary and dry toilet	26.2	2.60(1.37 ~ 4.93)	0.003	2.80(1.42 ~ 5.51)	0.003
Washing hands at critical moments	usually don not wash hands	15.1	1		1	
	one	28.3	2.22(1.24 ~ 4.01)	0.008	2.11(1.15 ~ 3.90)	0.017
	two	20.9	1.49(0.91 ~ 2.43)	0.116	1.52(0.91 ~ 2.53)	0.111
	three and above	16.9	1.14(0.66 ~ 1.97)	0.635	1.14(0.65 ~ 2.00)	0.660
Washing hand mode	soap	15.1	1		1	
	only water	21.0	1.50(1.04 ~ 2.15)	0.030	1.53(1.03 ~ 2.26)	0.034
Child's faeces treatment	sanitary	18.3	1		1	

Varaibles		Morbidity rate(%)	COR(95%CI)	P	AOR(95%CI)	P
	unsanitary	21.9	1.25(0.91 ~ 1.72)	0.167	1.56(1.11 ~ 2.20)	0.011
Underweight						
Drinking water source	purified tap water	3.9	1		1	
	protected well water	17.4	5.21(1.94 ~ 14.00)	0.001	4.28(1.46 ~ 12.52)	0.008
	unprotected well water	6.8	1.80(0.76 ~ 4.30)	0.185	1.87(0.77 ~ 4.52)	0.166
	others	17.2	5.12(1.80 ~ 14.53)	0.002	4.30(1.36 ~ 13.61)	0.013
Boiling before drinking	boiled	8.5	1		1	
	unboiled	7.6	0.89(0.56 ~ 1.42)	0.623	1.20(0.72 ~ 2.01)	0.491
Toilet type	flush sanitary toilet	2.4	1		1	
	flush unsanitary toilet	5.8	2.49(0.47 ~ 12.76)	0.274	2.48(0.48 ~ 12.77)	0.277
	sanitary and dry toilet	8.1	3.57(1.10 ~ 11.63)	0.035	3.03(0.92 ~ 9.98)	0.068
	unsanitary and dry toilet	12.5	5.81(1.69 ~ 19.94)	0.005	4.44(1.26 ~ 15.59)	0.020
Washing hands at critical moments	usually don not wash hands	3.8	1		1	
	one	9.2	2.57(0.92 ~ 7.17)	0.071	2.18(0.77 ~ 6.13)	0.141
	two	10.2	2.90(1.21 ~ 6.94)	0.017	2.77(1.15 ~ 6.65)	0.023
	three and above	6.3	1.71(0.65 ~ 4.46)	0.275	1.56(0.59 ~ 4.09)	0.370
Washing hand mode	soap	4.3	1		1	
	only water	10.3	2.57(1.42 ~ 4.66)	0.002	2.22(1.20 ~ 4.09)	0.011
Child’s faeces treatment	sanitary	5.8	1		1	

Varaibles		Morbidity rate(%)	COR(95%CI)	P	AOR(95%CI)	P
	unsanitary	11.2	2.07(1.29 ~ 3.31)	0.002	2.01(1.23 ~ 3.28)	0.005

Discussion

Malnutrition is still the main public health problem affecting children in poor rural areas in China. The results showed that the rates of normal development, stunting, underweight, wasting, overweight and obesity of children under 5 years old in Sichuan and Tibet were 69.0%, 19.8%, 8.0%, 5.2%, 4.6% and 1.8%, respectively. The rates of stunting, underweight and wasting were higher than those according to the 2009 China Food and Nutrition Monitoring system (CFNSS) [19] and Yu [12]. It is also higher than the survey results in other ordinary rural areas, poor areas and ethnic minority areas [20–25]. The malnutrition of children in the Tibetan and Sichuan minority areas is serious, which is quite different from that in other regions. Regional differences should be reduced by improving the regional economy, lifestyle and behavioural habits to reduce the incidence of malnutrition among children.

The rate of stunting in this survey was 19.8%, which was lower than the rate of 30.5% found in 2011 [26] but still much higher than the target rate of 7% in 2025 [13]. The change may be a result of the common effects of socioeconomic changes, child-feeding habits and environmental hygiene changes. The rate of stunting increased with age, and the rate of stunting in the group of 48 ~ 59-month-old boys was 37.5%, which is consistent with the findings of previous studies [27–30]. One possible explanation is that the children were malnourished for a long time, and the higher stunting rate accompanied increasing age.

The proportion of children who die of malnutrition remains high in low-income and middle-income countries; however, overweight and obesity rates are also on the rise [1]. Stunting and overweight/obesity often coexist in economically underdeveloped areas. According to one study, in 2006, the stunting rate of children in poor areas of central and western China was 57.6%, while the rate of overweight among children was as high as 16.8% [8]. Although the survey showed that the rate of overweight and obesity was slightly lower than that in other areas, it is worth noting.

A large number of studies have shown that the higher the family's economic level is, the lower the rate of child malnutrition [31–36]. A study conducted in Vietnam has shown that the impact of socioeconomic inequality on child malnutrition increases over time and that socioeconomic status is the first cause of inequality in stunting and the second cause of inequality in underweight [37]. The study found that the sanitation situation of the family in Sichuan and Tibet was poor, and the household sanitation of the families with different economic conditions was obviously different. The household environmental sanitation may have been affected by the economic situation of the family. Therefore, in multivariate statistical analysis, there is a collinearity problem between the two, and only one of them should be included in multivariate statistical analysis.

Our study showed that household sanitation had an important impact on the children's height and weight after adjusting for confounding factors. Thus, household sanitation may be a direct factor of the nutrition of children. Similar studies have shown that household sanitation facilities, water sources and household hygiene behaviours are major contributors to child malnutrition [38–40]. Poor sanitation is likely to have an impact on the nutritional status of children by increasing the risk that the children catch an infectious disease [41–44]. Therefore, intervention in household sanitation may reduce the malnutrition among children.

When we investigated some special areas and people groups, details about the economic situation were often difficult to obtain directly for a variety of reasons. For example, in our survey, 438 (45.4%) people were reluctant to disclose their family income. However, household environmental sanitation conditions can be easily obtained by observation, inquiry, etc. Therefore, when conducting similar research, we can replace the less accessible variables with variables that are more easily available for investigation and analysis to improve the feasibility of the survey and the effectiveness of the data. For example, in this study, we can infer the family economic situation through investigation of the family's environmental hygiene.

This study is a cross-sectional study, which cannot be used to draw causality conclusions. Further verification research should be carried out to clarify the impact of family hygiene conditions on the nutritional status of children.

Conclusions

The malnutrition of children in the Tibetan and Sichuan minority areas is serious. Stunting, underweight and wasting among children are obvious, especially the phenomenon of stunting, which is the most serious. The household sanitation status of the children is poor, household sanitation status differs greatly according to economic income, and household sanitation can be affected by the family's economic level. The relevant departments should increase family income while conducting household sanitation interventions, thereby improving household sanitation, reducing the morbidity and mortality resulting from malnutrition, and promoting the healthy growth of children.

List Of Abbreviations

PPS: Probability Proportional to Size; WHO: World Health Organization; HAZ: length/height-for-age; WAZ: weight-for-age; WHZ: weight-for-height; M±SD: median±standard deviation; CFNSS: China Food and Nutrition Monitoring system; UNICEF: The United Nations Children's Fund

Declarations

Ethics approval and consent to participate All procedures involving research study participants were approved by the Ethics Committee on Biomedical Research, Department of Medicine, Peking University.

Written informed consent was obtained from the caregivers of all the children involved in the study.

Consent for publication Not applicable.

Availability of data and materials The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests The authors declare that they have no competing interests.

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Authors' contributions HX designed and performed the study. XZ analyzed the data and results interpretation and wrote the paper. CLL and CX and MJL analyzed the data and paper modification. WJ, XFZ and YJL participated in data collection and quality control. All authors read and approved the final manuscript.

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